CHAPTER 6.0

ECOSYSTEM RESTORATION FOR FLOOD PLAIN AND FISHERIES RESOURCES

In addition to flood damage reduction, ecosystem restoration was studied. The intent of the restoration component is to reestablish the attributes of a functioning and self-regulating ecosystem, and to restore, to the extent possible, fish and wildlife habitat values in the Lower American River. As mentioned in Section 3.5, "Ecosystem Restoration Problems and Opportunities," the Lower American River has been significantly degraded by mining, development, flood plain constrictions (including bridges, levees, diversions, and the parkway system), dam construction, and flow modifications that have occurred over the past 150 years severely altered the physical processes that sustained natural habitat values within the ecosystem. Since the American River Parkway corridor contains all that remains of the historic flood plain and its associated aquatic, wetland, and riparian habitat, there is good cause for restoring these environmental resources.

A collaborative process was initiated between the Corps, SAFCA, MBK Engineers, and Jones & Stokes in September, 2000 to identify potential restoration sites. Four potential restoration sites on the Lower American River were identified through this process: Urrutia, Woodlake, Bushy Lake, and Arden Bar (Plate 6-1). Selection of these sites was based on the potential for addressing the largest number of restoration needs on any given site. This process narrowed the search to larger tracts of land within the lower portion of the American River Parkway corridor where multiple objectives could be achieved. Based on a recommendation from the Fish Working Group of the Lower American River Task Force that lowering temperatures in the American River would provide the greatest benefit to native fish species, modernization of the Folsom Dam temperature control shutters was added as an ecosystem restoration opportunity.

6.1 Flood Plain Restoration

6.1.1 Flood Plain Plan Formulation Process

The plan formulation process for the ecosystem restoration study purpose consists of these basic tasks:

- Establish specific objectives to address the problems and opportunities on the four sites for restoration on the Lower American River.
- Define constraints and criteria for formulating measures and alternatives.
- Develop ecosystem restoration measures including costs and benefits (qualitative and quantitative).
- Develop ecosystem plans from single or combined measures.

- Evaluate and compare alternatives and eliminate alternatives that do not meet the planning objectives and criteria.

- Identify an implementable National Ecosystem Restoration (NER) Plan for the Lower American River.

6.1.2 Flood Plain Planning Goals and Objectives

Planning goals and objectives were developed to address the identified ecosystem problems and opportunities in the study area. The ecosystem restoration goal is to restore Lower American River flood plain habitats and functions.

6.1.3 Flood Plain Objectives

The following objectives guided the formulation of restoration measures and alternative plans for the four sites:

- Restore diverse native plant communities.
- Restore native wildlife habitat.
- Establish connectivity between proposed and existing habitats.
- Reestablish hydrologic interaction between the flood plain and the river channel.
- Reduce potential for fish stranding on the flood plain.
- Restore shaded riverine aquatic habitat along the streambank.

6.1.4 Flood Plain Planning Constraints and Criteria

Overall Constraints

- Proposed ecosystem restoration plans should be consistent with the River Corridor Management Plan (RCMP) and the American River Parkway Plan.

- Proposed ecosystem restoration plans should incorporate a self-sustaining design and require minimal long-term maintenance.

- Avoid or minimize effects on existing high-quality vegetation with special emphasis on preserving elderberry shrubs.

- Avoid or minimize effects on existing and planned future recreation facilities in the American River Parkway. If changes are needed, relocation of facilities should be included in the restoration plan.

- Avoid or minimize effects on existing utility, gas, sewer, cable, and telephone infrastructure and access roads.

- Avoid effects to the existing flood control system including preservation of the flood capacity of the remnant flood plain.

- Avoid or minimize effects on or avoid known or potential cultural resources.

- Ensure consistency with applicable laws, regulations, and executive orders including the National Environmental Policy Act (NEPA), the Fish and Wildlife Coordination Act (FWCA), the Clean Air Act (CAA), the Clean Water Act (CWA), the Endangered Species Act (ESA), and the National Historic Preservation Act (NHPA).

Potential Ecosystem Restoration Sites

Ecosystem restoration sites were selected using the following criteria to evaluate restoration opportunities in the Lower American River:

- Available open space for ecosystem restoration
- Potential willingness of landowners
- Minimal potential to affect existing infrastructure and recreation
- Maximizing use of existing habitat and environmental resources
- Maximizing use of existing studies and available data
- Community support as expressed through the Lower American River Task Force

Based on this evaluation, the following four sites were identified as having a significant potential for achieving ecosystem restoration goals and objectives:

The Urrutia site consists of 251 acres located between river mile (RM) 1 and RM 2 on the north bank of the Lower American River (Plates 6-2 and 6-3). The site currently supports a privately-owned aggregate surface mining operation that is nearing completion of all mining activities. The site has been severely degraded as a result of past upstream land uses and the present extraction of sand and gravel. A reclamation plan that includes an appropriate end land use is required under State law. Reclaimed land under the State Mining and Reclamation Act (SMARA) is most commonly designated for permanent open space or agricultural use. This site would most likely be designated as open space because of the requirement for consistency with the American River Parkway Plan. The reclamation plan would also have provisions for a limited amount of onsite grading to establish appropriate gradients. This requirement combined with the site's existing degraded condition within the river's flood plain provides both problems and opportunities for restoration.

The Woodlake site adjoins the upstream end of the Urrutia site and spans the north bank between RM 2 and RM 4 (Plates 6-4 and 6-5). The site consists of 283 acres of open space on the river's edge located directly across the river from the highly urbanized central business district and downtown area of the city of Sacramento. The site lies fallow after recent cultivation as hay cropland. Yellow star thistle, a nonnative invasive weed, has infested the eastern edge of the site and is expected to expand its range, thereby reducing the capability for native trees, shrubs, and grasses to establish on the site's river terrace. Because nonnative species are

expected to continue taking advantage of the absence of hydrological influences and disturbed soils, this site is considered a good candidate for ecosystem restoration to reverse the expansion of nonnative invasive plant species and the associated ecological degradation within the Lower American River.

The Bushy Lake site consists of 337 acres located just upstream of the Woodlake site, between RM 4 and RM 5.5, on the north bank of the river (Plates 6-6 and 6-7). Bushy Lake covers about 12 acres of the site's central area. Cal Expo, an agency of the State of California, presently owns the flood plain. In 1976, the California State Legislature set Bushy Lake aside as a state preserve. The site was previously graded in anticipation of developing a golf course resulting in unnaturally high mounds and terraces and an expanded lake footprint. Approximately 10 acres of the site is used as overflow parking during the state fair. Two urban creeks, Chicken and Strong Ranch Sloughs, empty into the river at the site's easternmost boundary via a concrete channel after passing through the levee. The lack of a natural hydrological system to support the riparian plant species and wildlife around Bushy Lake and the decline of these species support the objective of restoring the Bushy Lake site.

The Arden Bar site consists of 280 acres located on the north bank of the river, between RM 12 and RM 13 (Plates 6-8 and 6-9). The site currently supports a 45-acre developed active-use park and a 33-acre training facility, surrounded by a levee, used by the Sacramento County Sheriff's Department. The site includes a 34-acre stocked fishing pond created from depressions remaining from past onsite mining activities. Much of the riparian edge habitat on the site is dominated by a singular dominant non-native invasive plant species, scarlet wisteria. Poor soil conditions and the predominance of oversized cobble prevent many native plant species from being able to establish on this site. The site provides an important opportunity to begin to arrest the spread of scarlet wisteria to other sites downstream and to restore riparian and wetland habitat along the fishing pond's edge and immediately adjacent to the river.

Constraints

Woodlake

- Elevation of the current flood plain is 31 feet above the 20-year flood event; this will restrict or limit the amount of riparian habitat restoration that can be achieved without significant excavation.
- Existing utility easements restrict the height of vegetation in the easement.
- Known and potential cultural resources would need to be integrated into restoration planning and design.

Urrutia

- The private property owner may not be a willing seller.
- Existing utility easements restrict the height of vegetation in the easement.

- Known and potential cultural resources would need to be integrated into restoration planning and design.

Bushy Lake

- Overflow parking for Cal Expo needs to be maintained.

- Disturbance of existing high-quality habitats, especially valley elderberry longhorn beetle (VELB) habitat, must be avoided to the greatest extent possible, and be effectively incorporated into the design and implementation of any restoration plan.

- Existing utility easements restrict the height of vegetation in the easement.

- Vehicular access to utility and radio towers must be maintained.

Arden Bar

- The existing Sheriff's training facility would need to be relocated and the levee surrounding the facility removed.

- Vehicular access to existing on-site telephone poles must be maintained.

- Existing moderate- to high-quality native vegetation, especially VELB habitat, should be avoided to the greatest extent possible and effectively incorporated into any restoration plan for the site.

Criteria

The ecosystem restoration alternatives were evaluated based on the following four planning criteria: (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability.

- **Effectiveness:** The extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities. An effective plan is responsive to the wants and needs of people and makes a significant contribution to the solution of an identified problem. Alternative plans with a high net increase in Habitat Evaluation Procedure (HEP) values were advanced.

- **Efficiency:** The extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment. Efficiency measures not only evaluate dollar costs, but also evaluate whether other resources are used efficiently in the construction and implementation of a plan; this is represented as "cost-effectiveness." Only cost-effective alternative plans were considered in the array of best buy plans and ultimate selection of the NER Plan.

- **Acceptability:** The workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies. The two primary components of acceptability are implementation including technological, environmental, economic, and social feasibility, and satisfaction. Alternative plans that were readily implementable and satisfactory to the Corps, Bureau, and local sponsors were considered in the final analysis and selection of the NER Plan.

- **Completeness:** The extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.

Benefit Evaluation

HEP Evaluation. The HEP was developed by the Service as an approach to a non-monetary evaluation procedure for use in project planning. HEP is a methodology that rates the quantity and quality of habitat in order to ascertain the combined effects of changes made by land and water development projects. It is also a tool used to document baseline information on habitats as a measurement for future habitat modification. The HEP method provides information for two types of wildlife comparisons: (1) the relative value of different areas, and (2) the relative value of the same area at some future time. In HEP, the quantity part of the formula is any measure of area (e.g., acres, hectares, square miles, or sections) appropriately sized for the study. The quality measurement of the formula is expressed in the form of an index that varies from 0 to 1 and measures how suitable the habitat is for the indicator species when compared to optimum habitat. In a HEP evaluation, an indicator species is selected based on a predicted increase or decrease in the habitat the species is known to rely upon for survival. The product of the quantitative and qualitative measures in the formula is expressed as a Habitat Unit (HU) (U.S. Fish and Wildlife Service 1980). For ecosystem restoration plan formulation, HUs are converted to Average Annual Habitat Units (AAHUs) or an annualized computation of HUs expressed as a derivation of habitat value across all years in the period of economic evaluation of the project

The USFWS established several site-specific goals in the HEP application that are keyed to existing fish and wildlife conditions, in an effort to determine how to develop and apply the HEP. These site-specific goals are: (1) to preserve or improve overall fish and wildlife habitat values to the extent feasible; (2) to minimize losses of any high-value habitat in the process of creating new habitat; (3) ensure no loss of any habitat values for raptors; and (4) improve habitat values for adult and juvenile Sacramento splittail and juvenile salmonids. Thirteen cover-types were identified for tracking in the HEP including two upland types: ruderal and grassland; six forest types: oak woodland/savannah, riparian oak woodland, mixed riparian forest, riparian forest/wetland, riparian forest, and small groups of trees (mature trees, cottonwoods, and black locust grove); four wetlands types: seasonal wetland, seasonal wetland "pits," seasonal wetland/shrub, and shallow aquatic. The evaluation species selected included the California vole, used primarily to ensure tracking of changes to the small mammal prey base of importance to various raptors that are known to use the sites. Although the vole model addressed the presence of small mammals for raptor prey (as well as presence of other wildlife), it was not

considered an indicator of relative availability of such prey to various raptors. To track prey availability, the food value element of the great-horned owl habitat suitability indicator (HSI) model was used. The key premises behind the food value element variables are that optimum owl foraging ability and success occurs where vegetative growth on the ground (either herbaceous or woody) is at least moderately dense and is between roughly 6 and 36 inches in height. The assumption is that as great-horned owl foraging conditions improve, so do foraging conditions for several other raptor species. Another variable considered was the existence of large, mature trees because such trees are important to a wide range of raptors for use as roosting, perching (for hunting or resting) and nesting substrates. This element was tracked in the analysis using the cover and reproduction value of the great-horned owl HSI model. The premise was that the larger the "patch" of forest and the larger the trees in the patch, the greater the owl cover and reproduction value. As with food value, an increase in the owl's cover and reproduction habitat value results in a corresponding increase for several other raptor species. Furthermore, by tracking the food value element combined with the cover and reproduction variables, these indices were found to be an effective way of tracking the basic attributes of forest areas, including riparian forest, which provides general habitat values to a wide range of other forest-dwelling birds, mammals, reptiles, and amphibians of the LAR, which in turn are effectively measured. The final attributes measured by the HEP are related to the seasonal floodplain habitat values, with particular emphasis on Sacramento splittail and juvenile anadromous salmonids. The Service's existing community-based HSI model for Shaded Riverine Aquatic (SRA) cover was considered for this accounting, but deemed inappropriate. The SRA cover model was found to focus on habitat variables important along a permanently flooded streambank. Such variables would not portray habitat values over much broader or more diverse floodplain areas where both inundation periodicity and duration vary widely. Therefore, a new (draft) community-based model for seasonally inundated floodplain habitat (Seasonal Floodplain Habitat Community Model – SFCM) of the Lower American River was developed and applied. The SFCM employs seven variables to derive HSIs in selected floodplain habitats. The theory behind the model is that habitat value for both splittail and juvenile salmonids is directly related to the amount of food and cover provided, duration of inundation, and type and degree of hydrologic connection of the floodplain to the river. The SFCM was applied, where applicable, for tracking habitat values in various occurrences of the four wetland cover-types. More detailed information on the HSI models, selected indicator species, and the calculation of Average Annual Habitat Units (AAHUs) that were derived from application of these models can be found in Volume III, Attachment 3, USFWS Coordination Act Report, of this study.

Flood Plain Restoration Measures

Measures are direct actions taken to achieve the restoration goals and objectives. The following measures were developed to meet multiple objectives.

Measure 1: Control Nonnative Invasive Plant Species Using Herbicide and Mechanical (Cutting, Mowing, Manual Extraction) Methods

Description. Nonnative invasive plant species thrive on sites where the soil and hydrological conditions have been altered through climatic and human-induced disturbances. Their presence prevents native plant communities from becoming reestablished, disrupts the food web of native wildlife species, and thereby reduces biodiversity.

This measure of controlling nonnative invasive plant species can be done through a combination of mowing or cutting and the application of herbicide. Any herbicide applied to the restoration sites would be a type that is suitable for use near aquatic habitat. Mowing should be done before the plants release seed. Densely infested areas (80-100 percent cover) would be delineated and management and control of species would be limited to areas immediately adjacent to the delineated area. As neither chemicals nor mowing nor cutting has proven 100 percent effective in eradicating yellow star thistle, maintenance and control is recommended for the life of the project. Other target species where this method would be effective include giant reed, Himalayan blackberry, sweet fennel, black locust, and scarlet wisteria.

Performance Standards. A program would be developed to ensure the success of this measure. The success of a nonnative invasive plant control program can be determined by observing reduced germination of plants in successive years in a treated area. Eighty percent eradication is a minimal, desirable future condition after five years of treatment.

Benefits. This measure would aid in the recovery of native plant communities as well as the nonnative wildlife communities. Measures that involve removing nonnative species were not evaluated using the HEP evaluation referred to in the "HEP evaluation" section. The restoration of native plant communities was identified as an objective of ecosystem restoration in the Lower American River Parkway by CALFED, RCMP, and the Lower American River Task Force.

Costs. The first cost is estimated at $1,050 per acre, and the operation and maintenance cost is estimated at $50 per acre per year.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Urrutia	All non-open water areas	100 to 190
Woodlake	All	180 to 280
Bushy Lake	All non-open water areas	125 to 334
Arden Bar	All non-open water areas	85 to 252

Measure 2: Control Nonnative Invasive Plant Species through Burning

Description. As with Measure 1, this measure involves controlling nonnative invasive plant species. This measure consists of an annual burning regime to control nonnative invasive plant species. The timing of the burn would be before plants go to seed and before the area has completely dried out to prevent fire escape.

Performance Standards. The success of a nonnative invasive plant control program would be determined by observing reduced germination of plants in successive years in a treated area. Eighty-percent eradication is the minimal desirable future condition after five years of treatment.

Benefits. This measure would aid in the recovery of native plant communities, prevent nonnative plant communities from becoming reestablished, support the food web for native wildlife species, and increase biodiversity.

Costs. The first cost of this measure is estimated at $50 per acre, and the operation and maintenance cost is estimated at $50 per acre every 3 years.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Urrutia	Higher flood plain areas with ruderal vegetation	10 to 50
Woodlake	Higher flood plain areas with ruderal vegetation	10 to 130
Bushy Lake	Higher flood plain areas with ruderal vegetation	10 to 30

Measure 3: Remove Nonnative Invasive Plant Species through Excavation of the Seed Bank

Description. This measure involves eradicating nonnative species by excavating the top six to twelve inches of soil and removing the fill from the site. This method is particularly useful in eradicating yellow star thistle. The excavated material could be used to fill open waters and pits as the seeds for most of these species, especially yellow star thistle, will not germinate under water. Another option, if the soil were suitable, would be to store it offsite and use it for levee construction material. Even with implementation of long-term herbicide and burning management programs, star thistle seeds tend to persist in the topsoil layers. Other target species for this method would be sweet fennel, giant reed, and pampas grass.

Performance Standards. The success of a nonnative invasive plant control program would be determined by observing reduced germination of plants in successive years in a treated area. Eighty-percent eradication is a minimal, desirable future condition after five years of treatment.

Benefits. This measure would aid in the recovery of native plant communities. This measure is very effective in removing the nonnative invasives because seeds are removed. Once established, native grasslands would out-compete nonnative grasses and forbs.

Costs. The first cost of this measure is $12,500 per acre. No operation and maintenance, or construction costs are associated with this measure.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Urrutia	Higher flood plain and other infested areas	100
Woodlake	Higher flood plain and other infested areas	130
Bushy Lake	Higher flood plain and other infested areas	110
Arden Bar	Higher flood plain and other infested areas	85

Measure 4: Plant Seasonal Wetland Plant Species

Description. This measure addresses the historical loss of seasonal wetlands in the Lower American River flood plain. Very little seasonal wetlands of any quality remain along the Lower American River. This measure involves planting plugs of rushes *(Juncus* spp.*)* and tules *(Scirpus acutus)* at a spacing distance of 10 feet on center. Species would be planted in clusters so that the hydrology of the site would carry seed from the plugs to unplanted areas. No irrigation is recommended for seasonal wetland areas; however, the site should be maintained for five years by keeping it weed-free and replacing dead plants, as necessary.

Performance Standards. Initially-planted species should have an 80-100 percent survival rate over the first 3 years. Unplanted areas should begin to show evidence of recruitment of native wetland plant community species. At the end of 5 years, the wetland would be expected to support 100 percent coverage of native wetland species.

Benefits. This measure would increase the amount of seasonal wetland habitat available for use by native wildlife for nesting and forage. Seasonal wetlands are very scarce in the Lower American River, and implementation of this wetlands measure would increase this scarce resource.

Costs. The first cost of this measure is estimated at $7,000 per acre, and the operation and maintenance cost is $1,500 per acre per year. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Woodlake	West	2 to 15

Measure 5: Grade the Flood Plain to Lower Flood Plain Elevations to Levels that can Support Seasonal Wetland Species (Including Plant Installation).

Description. Precise grades for the appropriate hydrology on each restoration site should be determined before excavation and planting. Excavated soils need to be removed from individual sites for disposal, stockpiled for later use as levee construction material, or used for restoration purposes at other sites in the Lower American River corridor. Graded areas would be

planted with native wetland plant species or could be designed to allow for the creation of seasonally inundated mudflats.

Performance Standards. Initially, planted species should have an 80-100 percent survival rate over the first 3 years. Unplanted areas should begin to show evidence of recruitment of native wetland plant species. At the end of 5 years, the wetland should have 100 percent coverage of native wetland plants.

Benefits. This measure would increase the amount and quality of seasonal wetland habitat in the Lower American River flood plain that is available for use by native wildlife for nesting and forage. Other benefits include flood plain values of restoring hydrologic connectivity and allowing for natural regeneration of native plant communities.

Costs. The first cost is estimated at $33,000 per acre. The operation and maintenance cost is estimated at $1,500 per acre per year. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Bushy Lake	Perimeter of lake	16 to 22
Woodlake	West (lower floodplain elevations)	2 to 15

Measure 6: Plant Riparian Forest Species

Description. Due to the altered hydrology of the Lower American River flood plain and competition from nonnative invasive species, riparian forest species are not regenerating. Riparian forests are a valuable resource in the Lower American River. They are used for cover, perching, and nesting for wildlife.

This measure would involve planting various riparian forest species. The following species with their corresponding size at time of planting are recommended for areas designated for planting as riparian forest:

Common and Scientific Names	Size
Fremont cottonwood *(Populus fremontii)*	1 gallon
Sycamore *(Platanus racemosa)*	1 gallon
Oregon ash *(Fraxinus latifolia)*	1 gallon
Box elder *(Acer negundo)*	1 gallon
White alder *(Alnus rhombifolia)*	1 gallon
Red willow *(Salix laevigata)*	24-inch cuttings
Yellow willow *(Salix lasiondra)*	24-inch cuttings
Sandbar willow (*Salix hindsiana)*	24-inch cuttings
Goodding's willow *(Salix gooddingii)*	24-inch cuttings
California blackberry *(Rubus ursinus)*	1 gallon

Tree species would be planted at 30 feet on-center. Plastic shelters are recommended for all tree species. Irrigate rooted material for one year using time-released water package (TRWP) or another similar method. Maintain planted area for five years by keeping it weed-free, replacing dead plants, and replacing TRWPs and tree shelters, as necessary.

Performance Standards. Some mortality can be expected from deer browse and beaver damage. While it is not possible to predict mortality from wildlife, the success of the riparian forest becoming self-sustaining is dependent on maintaining survival rates above 80 percent.

Benefits. The size of riparian forest areas would be enlarged. This would provide better cover, shelter, and nesting habitat for migratory songbirds and other native wildlife. The net AAHU gain per acre of riparian forest would range from 0.20 to 0.34 depending on specific site conditions.

Costs. The first cost of this measure is estimated at $8,000 per acre. The O&M cost is estimated at $2,500 per acre per year. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Bushy Lake	Edges of Bushy Lake	2 to 4
Arden Bar	Island in pond	1
Woodlake	Adjacent to depressional wetland	6 to 10

Measure 7: Lower Flood Plain Elevations to a Level that will Support Riparian Forest Species (Including Plant Installation).

Description. Each site requires specific grading to lower the land surface elevation needed to establish the hydrology that will support riparian forest species. Excavated material would be removed from the site for disposal, stockpiled for levee construction material, or used for restoration purposes at other sites in the Lower American River corridor.

It is recommended that tree species (see plant list under Measure 6) be planted at 15 feet on center. Plastic tree shelters are recommended for all tree species to prevent damage from beavers and deer browse. Irrigation of rooted material for 1 year using TRWP would also be needed. Maintenance activities during the first 5 years of establishment would include keeping the area weed free, replacing dead plants, replacing the TRWPs and tree shelters, as necessary.

Performance Standards. Some mortality of riparian forest species would be expected from deer browse and beaver damage. While it is not possible to predict mortality from wildlife, the success of the riparian forest becoming self-sustaining is dependent on maintaining survival rates above 80 percent.

Benefits. The size of riparian forest areas would be enlarged providing better cover, shelter, and nesting habitat for migratory songbirds and other native wildlife. The net AAHU

gain per acre of riparian forest would range from 0.29 to 1.19, depending on specific site conditions.

Costs. The first cost of this measure would be $34,000 per acre. The operation and maintenance cost would be $2,500 per acre per year. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Urrutia	Adjacent to Bannon Slough/flood plain	25 to 65
Woodlake	Southwest and near cross channel	4 to 16
Bushy Lake	Northwest and edges of Bushy Lake	15 to 22
Arden Bar	Along proposed high-flow channel and fish pond	5 to 31

Measure 8: Plant Riparian Oak Woodland Species

Description. Much of the Lower American River's existing riparian oak woodland lies in small, fragmented remnant patches. Larger, connected expanses of oak woodland would provide better wildlife habitat. This measure restores riparian oak woodland species by planting.

The following species would be planted 30 feet on-center. Tree species would be protected with plastic shelters during the first 2-3 years of the establishment period.

Common and Scientific Names	Size
Valley oak (*Quercus lobata*)	50% acorns/50% 1 gallon
Black walnut (*Juglans hindsii*)	1 gallon
Oregon Ash *(Fraxinus latifolia)*	1 gallon
California Wild Rose *(Rosa californica)*	1 gallon
California Blackberry *(Rubus ursinus)*	1 gallon

This measure includes irrigating for two years using TRWPs or another similar method. It also includes maintenance for five years by keeping weed-free, replacing dead plants, replacing TRWPs and tree shelters, as necessary.

Performance Standards. Planted oaks would rely heavily on supplemental irrigation for the first several years. The density of the planting factors includes a loss of 10-15 percent. A minimum of 80 percent survival of planted oak species after 10 years is recommended.

Benefits. The benefits of restoring the riparian valley oak woodland areas include providing better cover, shelter, and nesting habitat for migratory songbirds and native wildlife. The net AAHU per acre would be about 0.23 AAHUs. In addition, other benefits include flood

plain values of restoring hydrologic connectivity and allowing for natural regeneration of vegetation.

Costs. The first cost of this measure is $15,500 per acre. The operation and maintenance costs are $3,000 per acre for the first year and $2,000 per acre per year thereafter. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter. The establishment period is estimated at 10 years for shrubs. Fifty years would be required to reach a full-functioning value.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Urrutia	East	5 to 11
Woodlake	South and north	4 to 12
Bushy Lake	East of Bushy Lake	2 to 3

Measure 9: Plant Oak Savanna Species

Description. Extensive areas of oak savanna habitat have been lost in the Central Valley region as land has been converted for development and agriculture. Restoring large, unfragmented areas of oak savanna would benefit the native wildlife that relies on habitat provided by this plant community.

This measure involves planting oak savanna species. The same species proposed for conversion to oak woodland are also recommended for oak savanna. The spacing, however, should be 150 feet for tree species and 50 feet for shrub species, or three shrub species for every oak or walnut tree planting, on average. The planting pattern would take the form of clusters of trees and shrubs with significant open area between the plantings to retain the character of a savanna. The remaining area would be seeded with a native grass mix. Eradication of existing annual or perennial nonnative grasses would be required before seeding. All tree species should be protected with plastic shelters. Irrigation for two years using TRWPs, or another similar method, and maintenance for five years by keeping weed-free, replacing dead plants, replacing TRWPs, and tree shelters would be necessary.

Performance Standards. Planted oaks would rely heavily on supplemental irrigation for the first several years. The density of the planting factors includes a loss of 10-15 percent of oak species. A minimum of 80 percent survival of planted oak species after 10 years is recommended.

Benefits. The size of oak savanna areas would be enlarged to provide better cover, shelter, and nesting habitat for migratory songbirds and native wildlife. The net AAHU gain per acre would be 0.21 to 0.26 AAHU per acre.

Costs. The first cost would be $14,300 per acre and the O&M cost would be $2,000 per acre for the first year and $1,500 per acre per year for 5 years during the first 10 years; once every 5 years thereafter.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Woodlake	Northeast and east	8 to 19
Bushy Lake	South	50 to 70
Arden Bar	Southwest, along maintenance road, river bend	1.5 to 25

Measure 10: Seed Grassland

Description. Large, unfragmented areas of grasslands have been in decline due to land conversion to agriculture, development, and infestation of nonnative invasive species, such as yellow star thistle. Before this measure would be implemented, several measures to remove nonnative invasive species would be applied (see Measures 1-3). The flood plain would be disced before drilling or broadcasting seed. A native grass mix appropriate for flood plain ecosystems such as California brome, blue wild rye, meadow barley, Baltic, Nodding needlegrass, California broom, California buckwheat, and tomcat clover would be used. No irrigation is recommended, but grasslands should be kept weed-free for five years using spot spraying of herbicides and manual removal of nonnative invasive species, as necessary.

Performance Standards. Newly-seeded grassland is susceptible to invasion by nonnative invasive species, such as yellow star thistle. Aggressive eradication of nonnative species would improve the success of establishing native grassland. Target performance of the new grassland should be 90-100 percent coverage by native grasses.

Benefits. Large, connected expanses of grassland are vital habitat for many native wildlife species and provide excellent foraging habitat for raptor species. The net AAHU gain is 0.15 AAHU per acre.

Costs. The first cost of this project would be $3,000 per acre. The O&M cost is estimated at $2,000 per acre per year. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter. The establishment period is 15 years to reach full-functioning value.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Urrutia	East	4 to 10
Woodlake	Interior	60 to 95
Bushy Lake	Southwest	10 to 40

Measure 11: Provide Downed, Large Woody Material to Construct Brush Piles

Description. Due to the operation of Folsom Dam and the abandonment of the flood plain by the main American River channel, very little recruitment of woody material makes its way onto the flood plain. Woody material is valuable to native wildlife as it is used for shelter, cover, and nesting. Brush piles are utilized by wildlife as both shelter and nesting habitat. This measure would involve collecting downed, large woody material from the site and placing in loose piles around the site in scattered locations. The loose piles of material would have sufficient internal space for resident small mammals to use.

Performance Standards. The brush piles should be monitored annually to determine if they are being used by wildlife.

Benefits. Brush piles are used by wildlife as both shelter and nesting habitat. This measure cannot be quantified using the HEP program. Material from removed nonnative invasive tree species could be used for piles thereby reducing the need for disposal off-site.

Costs. The first cost of the measure is $500 per acre. The O&M cost is estimated at $250 per acre per year every two years.

Areas of Potential Applicability

Site	Areas in Site	Acreage
All	Higher flood plain areas	

Measure 12: Manage Grassland as Hay Crop for Raptor Forage

Measure 12 was dropped from further consideration because it was determined to be a management measure, rather than an ecosystem restoration measure.

Measure 13: Modify Hydrology and Construct Side-Channels off the Main American River Channel and Plant Shallow Aquatic, Seasonal Wetlands, and Riparian Forest Species

Description. To provide suitable habitat for both Sacramento splittail (Federally-listed species) and anadromous salmonid fish species, this measure proposes excavating a side channel into the flood plain. The intent of this channel is to provide habitat for splittail, salmon, and steelhead by establishing woody riparian vegetation in the flood plain and providing a connection to the river at the downstream end. Excavated material would need to be removed from the site for disposal, stockpiled for levee construction material, or used for restoration purposes at other sites within the Lower American River corridor. The resulting side-channel should be planted with seasonal wetland and riparian forest species as outlined in Measures 4 and 6, respectively.

Performance Standards. The side channels would be monitored annually for habitat suitability for use by fish. Bank stability would also be monitored to ensure no sedimentation of

the shallow aquatic area is occurring from adjacent banks or that degradation of the side channel is not resulting from floodflows.

Benefits. This measure addresses specific needs of the endangered Sacramento splittail, salmon, and steelhead fish species. This measure could assist in the recovery and return of these species to the American River system. The net AAHUs per acre for this measure are 1.87 to 1.98 AAHUs. In addition to habitat restoration benefits, this measure would also increase localized flood capacity of the channel.

Costs. The first cost is estimated at $74,500 per acre and the O&M cost is estimated at $2,500 per acre per year. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter. The establishment period is 5 years. Fifty years would be required to achieve full-functioning habitat value.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Urrutia	South	25 to 30
Woodlake	Southwest	30 to 34
Bushy Lake	Southeast	3 to 5

Measure 14: Construct a High-Flow Bypass Channel

Description. This measure involves excavating a natural channel near the active river channel to provide a high-flow bypass. On-site cobble should be used to create the streambed. Banks of the channel should be planted with riparian scrub species such as willow. Excavated material would need to be removed from the site for disposal, stockpiled for levee construction material, or used for restoration purposes at other sites within the Lower American River. A control structure would be required at the inlet to the channel to ensure that only high flows go through the channel. The outlet should be at a grade one foot below the existing toe of the bank and graded to provide a small backwater area off of the main river channel.

Performance Standards. The side channels should be monitored annually for stability of the banks to ensure no sedimentation of the shallow aquatic area is occurring from adjacent banks that could interfere with fish habitat.

Benefits. The channel would provide backwater, or lentic habitats beneficial to native anadromous fish species including splittail and chinook salmon and steelhead. The net AAHUs/acre is estimated at 0.45. Other benefits of the high flow bypass channel include reduced hydraulic pressure on steep banks susceptible to erosion.

Costs. The first cost is estimated at $73,500 per acre. The O&M cost is estimated at $2,500 per acre per year every five years.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Arden Bar	River side of fish pond	7

Measure 15: Terrace Steep, Degraded Riverbanks and Plant with Riparian Forest Species

Description. As the main channel of the American River has incised, its adjacent banks have become steep and unable to support riparian vegetation. Wide bands of riparian vegetation immediately adjacent to the main channel, critical areas for both flood plain and aquatic wildlife species, have been lost.

This measure would involve grading existing, steep banks with one bench at 10- to 20-foot minimum width. Additionally, an upper bench of the same size can be incorporated into the design. The measure should be designed to preserve existing mature vegetation where possible. Excavated material would be removed from the site for disposal, stockpiled for levee construction material, or used for restoration purposes at other sites within the Lower American River corridor.

Performance Standards. The side channels should be monitored annually for suitability of use by fish. Bank stability should also be monitored to ensure no sedimentation of the shallow aquatic area is occurring from adjacent banks. The banks should be monitored annually for erosion and sedimentation and establishment of riparian forest plant communities.

Benefits. Creating benches in the bank and planting with riparian forest species would improve the quality of near-river habitat. The net AAHU gain per acre is estimated at 1.88 to 2.06. This measure would also increase the hydrological interaction between the main channel and the flood plain.

Costs. The first cost is estimated at $ 133,000 per acre and the O&M cost is estimated at $2,500 per acre per year. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter. The establishment period is 5 years. Fifty years would be required to achieve full-functioning value.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Urrutia	Mining pit banks and adjacent to river	2.5 to 25
Bushy Lake	Southeast	4 to 10

Measure 16: Restore Connectivity between the River Corridor and Flood Plain by Lowering Berms

Description. In some locations along the Lower American River, artificial berms separate the river channel from adjacent lower elevation depressions. These berms were likely

created by either excavating the land adjacent to them or through stockpiling of unused material in the construction of road and train floodplain crossings. Presently, these berms are used as unimproved roads and trails and provide little habitat value. These berms are characterized by steep, unstable banks on the river side and by mixed non-native and native woody riparian species and barren areas on the land side. By breaching these berms, the depressions would be more frequently inundated by flows from the river channel and, in turn, provide the hydrology needed for the growth and survival of wetland plant communities. Presently, these narrow berms obstruct the river channel from these depressions. Given the loss of many wetland areas adjacent to the river channel, breaching these berms would allow for the rehabilitation of these depressions into functioning wetlands. In the case of Woodlake, simply removing approximately one acre of earth would allow for the inundation of approximately 5.5 acres of potential wetland habitat. The excavated material may be used onsite to develop landforms or would need to be removed from the site for disposal, stockpiled for levee construction material, or used for restoration purposes at other sites in the Lower American River corridor.

Performance Standards. Presence of water in the wetlands during a 1.5-year flow is an indication that connectivity to the river corridor has been restored.

Benefits. The artificial berms block moderate flows from inundating areas that would function as seasonal wetlands. Reintroducing flows to these wetlands would increase the diversity of plant and wildlife communities. This measure would result in an increase of the scarce seasonal wetland habitats. Additionally, this measure would increase hydrological interaction between the main channel and the flood plain. The net gain in AAHUs per acre is estimated at 0.49 to 1.22.

Costs. The first cost of this measure is estimated to be $61,500 per acre. The O&M cost is estimated at $2,000 per acre per year. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter. The establishment period is 5 years. Fifty years would be required to achieve full-functioning value.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Woodlake	Southwest	1 to 2

Measure 17: Construct Low-Elevation Bank Benches in Interior Open Waters and Plant with Emergent Wetland Species

Description. The banks of both Arden Pond and Urrutia Pit are either devoid of vegetation or colonized by nonnative invasive plant species that are effectively reducing biodiversity and wildlife habitat on these sites. Benches with emergent vegetation would provide a transition between the open water area and the riparian scrub and forest habitat area. This measure would involve planting plugs of emergent wetland species at 15 feet on-center. The planting pattern should take the form of cluster planting so that the hydrology of the site would assist in carrying seeds from the plugs to unplanted areas. The recommended species for planting are rush (*juncus sp.*) and tules (*Scirpus acutus)*. No irrigation is recommended. The site should be maintained weed-free for five years.

Performance Standards. Presence of water in the wetlands during a 1.5-year flow.

Benefits. Emergent wetlands provide excellent waterfowl and migratory bird nesting habitat and shelter. The benches would provide a more gentle transition between the open water and the bank slope and assist with bank stabilization. The net AAHU gain per acre ranges from 0.26 to 0.33.

Costs. The first cost of this measure is $20,500 per acre. The O&M cost is $2,000 per acre. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Urrutia	Edge of Urrutia pond	2 to 7
Arden Bar	Around fish pond	0.5 to 1.5

Measure 18: Create Outlet Stream Channel from Bushy Lake to the American River, and Plant with Riparian and Wetland Vegetation

Description. A naturalistic stream channel approximately 30-feet wide from top of bank to top of bank would be designed and excavated to convey water from the southwest corner of Bushy Lake to the American River. The channel would begin to receive water when the water surface elevation of Bushy Lake begins to exceed 5-feet in depth. In a conceptual design scenario using existing topographic data provided by Ayres Associates, this elevation was 24.5-feet. Excavated material could be reused onsite to fill in portions of Bushy Lake that were excavated at the time of the preliminary golf course development on the flood plain (in the 1970s) to achieve the objectives of Measures 5 and 7. The banks of the channels would be planted primarily with wetland vegetation. Some riparian forest species would be planted to increase wildlife habitat adjacent to the channels. The precise width-to-depth ratio of the channels would be determined by analyzing the total hydrology available to the flood plain. To avoid infestation of the newly-created channels by nonnative invasive plant species, the areas would need to be planted immediately and maintained until the ground vegetation has filled in or throughout the life of the project.

Performance Standards. The channel would be designed so that the available water would be sufficient to support the new wetland and riparian forest vegetation. Monitoring would be required to ensure vegetation establishment and erosion control.

Benefits. The primary beneficiaries of this measure would be fish species, insects, and microorganisms in the Lower American River. These species are a key link in the food web of the corridor, thereby providing benefit for avian and terrestrial species. The wetland and riparian vegetation would provide a benefit to bird species by creating nesting habitat. This measure would reestablish a hydrological connection between Bushy Lake, Chicken and Strong Ranch Sloughs and the Lower American River.

Costs. The first cost of this measure is $33,000 per acre. The O&M cost is $1,500 per acre. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter. The establishment period is 5 years. Fifty years would be required to achieve full-functioning value.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Bushy Lake	From and into Bushy Lake	1 to 5

Measure 19: Divert Water Flows above 2 cfs from Chicken and Strong Ranch Sloughs to a Storage Wetland adjacent to Bushy Lake.

Description. This measure would allow Bushy Lake to avoid fluctuating water levels with periods of desiccation by creating a reliable, constant, and managed source of water. This measure calls for diverting water from Chicken and Strong Ranch Sloughs into a 6-acre storage wetland located immediately adjacent and east of Bushy Lake and, after a residence time of 7 to 10 days, into Bushy Lake. An 1800 rpm lift pump (Measure 25) would be installed between the levee and the existing detention basin on the north side of the levee at the end of Ethan Way. Depending on the optimum water management level established for Bushy Lake and the season, 1 to 3 cfs would be pumped from the sloughs through about 2300 feet of 16-inch PVC pipe before being discharged into the wetland.

The wetland would be created by excavating approximately 2 feet down into the floodplain and using the excavated material to create a berm around the perimeter of the wetland. The berm would be wide enough to allow for its use by maintenance vehicles and about 2 feet higher than the existing floodplain elevation. The berms would be seeded with a mixed native and non-native grass seed mix. The top of the berm would be compacted and topped with gravel. After excavation, the wetland would be lined with clay to assist in water retention. The interior of the wetland would be planted with tules (*Scirpus acutus*) and cattails (*Typha latifolia*); plant species that would be recruited naturally once established. Vegetation would be harvested or supplemented to maintain coverage of the wetland between 60 and 70 percent. Water level in the wetland would be maintained between 2- to 3-feet in depth and be controlled by an overflow weir. Water entering into the wetland would first enter a sediment-settling basin before flowing over a low weir to supply water to the wetland. The sediment basin would require clean out on a regular basis. A long-term operations, management, and maintenance plan would be required for the entire system.

Further description of this measure can be found in the Bushy Lake Ecosystem Restoration Technical Study (December 2001) attached to this document, specifically in Volume II, Attachment 5.

Performance Standards. As part of a comprehensive operations, maintenance, and management plan for the onsite wetlands, performance standards would need to be established to guide monitoring. In general, wetlands should be monitored for vegetative cover, nutrient uptake, contaminant removal, wildlife use, mosquitoes, and proper functioning of the lift pump.

Benefits. The benefit of this measure would be improved wetland habitat quality and values.

Costs. The first cost for this measure is $384,966. Maintenance costs are estimated at about 3 to 5% of construction or first costs, or an annual cost of $19,250 for the life of the project

Areas of Potential Applicability

Site	Areas in Site	Acreage
Bushy Lake	Between detention basin and Bushy Lake	6 to 10

Measure 20: Improve the Flow of Water from Sump Pump No. 152 Eastward to Bushy Lake by Removing Metal Fence and Dredging the Channel Bottom to Reestablish a Low-Flow Channel

Description. This measure involves restoring the existing channel from Sump Pump No. 152 to Bushy Lake. To reestablish a low-flow channel, a channel would need to be dredged and obstacles such as the existing metal fence and the debris and vegetation that has accumulated on the west side of the fence would be removed. The second component would be to recreate a meandering low-flow channel with positive drainage towards Bushy Lake. The dredged material could be used to recreate flood plains in the channel or removed from the site.

Performance Standard. Positive drainage from the sump pump outlet to Bushy Lake indicates that the flow of water has been improved.

Benefits. The benefits of this measure would include increased flow to Bushy Lake, as well as conversion of existing vegetation in and around the lake. By adding more water to Bushy Lake during the summer months when it needs it most, this measure could potentially raise the surface water elevation of the lake which would help suppress duckweed growth in the lake and cocklebur growth in the "fingers."

Costs. The first cost of this measure is $13,500. The O&M cost is $3,000 every three years. The establishment period is 2 years. Ten years would be required to achieve full-functioning value.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Bushy Lake	Channel at toe of levee	1 to 3

Measure 21: Fill and Plant with Native Riparian Oak Woodland Species

Description. Using excess material from excavations described in other restoration measures, raise the elevation of the flood plain to expand selected riparian oak woodland habitat.

The following tree species would be planted 30 feet on-center and protected with plastic shelters:

Common and Scientific Names	Size
Valley oak (*Quercus lobata*)	50% acorns/50% 1 gallon
Black walnut (*Juglans hindsii*)	1 gallon
Oregon Ash *(Fraxinus latifolia)*	1 gallon
California Rose *(Rosa californica)*	1 gallon
California Blackberry *(Rubus ursinus)*	1 gallon

Newly-planted trees would require irrigation for 2 years using TRWDs, or a similar method, and maintenance for five years by keeping the area weed-free, replacing dead plants, and replacing TRWDs and tree shelters, as necessary.

Performance Standard. Planted oaks would rely heavily on supplemental irrigation for the first several years. Planting density factors in a loss of 10-15 percent of oak species. A minimum of 80 percent survival of planted oak species after 10 years is recommended.

Benefits. Much of the existing oak woodland lies in small, fragmented remnant patches. Re-creating larger, connected expanses of oak woodland would provide better wildlife habitat that more closely resembles the habitat that existed before construction of Folsom Dam. Implementation of this measure would enlarge the size of oak woodland areas, thereby providing better cover, shelter, and nesting habitat for migratory songbirds and native wildlife.

Costs. The first cost is estimated at $53,000 per acre. The O&M cost is estimated at $3,000 per acre in the first year and $2,000 per acre thereafter. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter. The establishment period is 10 years. Fifty years would be required to achieve full-functioning value.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Arden Bar	Along maintenance road	2 to 3.5

Measure 22: Plant Banks of Proposed High-Flow Bypass Channel with Willow Species

Description. Plant 24-inch length (and larger) willow cuttings in cobble banks of the bypass channel. No irrigation would be required. This measure would only be done in conjunction with Measure 14.

Performance Standard. The willow cuttings should have a survivability rate of 80 percent after five years.

Benefits. This measure would increase bank stability of the proposed high-flow bypass channel while increasing its habitat value. Once the willows reach maturity, they would provide shelter and nesting habitat.

Costs. The first cost of this measure $2,500 per acre, and the O&M cost is estimated at $1,500 per acre. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter. The establishment period is 5 years. Fifty years would be required to achieve full-functioning value.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Arden Bar	Edges of proposed high-flow bypass channel	0 to 4.5

Measure 23: Create Shallow Aquatic Habitat at the Outlet of the Proposed High-Flow Bypass Channel to Create Permanent Lentic Habitat for Native Fish Species

Description. This measure would be constructed in conjunction with Measure 14. The area would be graded to one foot below the low-water elevation to provide permanent backwater.

Performance Standard. The shallow aquatic habitat should be monitored annually for suitability of use by fish. Bank stability should be monitored to ensure no sedimentation of the shallow aquatic area is occurring.

Benefit. Anadromous fish need slow waters located off the main channel for resting during their migration upstream. Many of these side-channels and shallow aquatic areas along the Lower American River have been depleted as a result of changes in the river channel created from hydraulic mining and the construction of upstream dams. This measure addresses specific needs of anadromous fish. This measure could assist in the recovery and return of these fish to the American River system.

Cost. The first cost is $67,500 per acre, and the O&M cost is $1,500 per acre. The operation and maintenance interval would extend for 5 years during the first 10 years and once every 5 years thereafter. The establishment period is 5 years. Fifty years would be required to achieve full-functioning value.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Arden Bar	Outlet of proposed high-flow bypass channel	0.5 to 0.75

Measure 24: Remove Levee from around Sheriff's Training Facility and Reuse or Dispose of Material

Description of Actions. Excavate the material creating the levee surrounding the Sheriff's Training Facility and dispose of it at an appropriate facility. Material could be reused onsite to reduce the size of the pond and to meet the needs of Measure 21.

Performance Standard. The Sheriff's Training Facility area should be surveyed to determine that a constant surface elevation has been established by removal of the levee and grading.

Benefits. The levee is a non-conforming use within the parkway. The levee acts as a barrier to movement of large wildlife within the parkway. This measure will assist in restoring hydrological processes by allowing occasional high flows to pass through this area.

Costs. The first cost of this measure is estimated at $693,000 or 77,000 per acre. There is no O&M cost.

Areas of Potential Applicability

Site	Areas in Site	Acreage
Arden Bar	Around Sheriff's Training Facility	9.0

Measure 25: Install Pump and Delivery System to Divert Flows above 2 cfs from Chicken and Strong Ranch Sloughs to the Bushy Lake (Cal Expo) Flood Plain

Description. This measure should be considered only in conjunction with Measure 7 and 18 for the Bushy Lake site. An 1,800 rpm lift pump would be installed on the levee to divert flows above 2 cfs from Chicken and Strong Ranch Sloughs through approximately 2,300 feet of 16-inch PVC pipe leading to a storage wetland adjacent to Bushy Lake.

Performance Standard. The proper operation of the pump delivery system to the channel should be monitored monthly to ensure it is pumping and delivering an appropriate amount of water from the sloughs.

Benefits. The primary benefit of this measure is to assist in the restoration of a more natural hydrological process to Bushy Lake and provide a reliable and manageable source of water. In conjunction with Measure 19, this measure would also have incidental water quality benefits.

Costs. The first cost of this measure is estimated at $304,693. The O&M cost is estimated at $6,500 to $8,200 per year. The range in costs captures the rising cost of electricity.

6.1.5 Measure 26: Purchase Land

Description. This measure consists of purchasing land necessary for implementation of all of the ecosystem restoration measures. Real estate requirements and costs are incorporated into the individual measures formulated for each restoration site.

Costs. The following real estate acquisition costs were determined for each restoration site:

Restoration Site	Acquisition Cost
Arden Bar	$112,000
Bushy Lake	$458,000
Urrutia	$910,880
Woodlake	$475,000

6.1.6 Screening of Flood Plain Ecosystem Restoration Measures Evaluation of Ecosystem Restoration

Initial Screening of the Measures

The measures, annual cost, first cost, and benefits considered at each site are summarized in Tables 6-1 through 6-4. As shown in these tables, one or more scale, or sizes, of each measure were chosen for use in the initial screening of measures.

6.1.7 Cost Effectiveness and Incremental Cost Analysis of Flood Plain Restoration Measures

The average annual equivalent costs and benefits (average annual habitat units) from Tables 6-1 through 6-4 were used to conduct CE/ICA. IWR-Plan Decision Support software version 3.0 was used for the analysis. This initial analysis was completed on a site-by-site basis. IWR-PLAN first builds all possible alternative plan combinations based on the potential combinations of measures, whether the measures can be combined with each other, and whether any measures are dependent on each other. In some flood plain cases, certain measures are dependent on each other. For all four flood plain sites, all measures were dependent on purchasing the land (Measure 26) and the eradication of nonnative invasive plant species (Measures 1 and 3). For the Woodlake site, to maintain existing good raptor habitat, all other measures were dependent on measure 10 (seed grassland). For the Bushy Lake site, Measures 5 (restore wetlands), 7 (grade flood plain and plant riparian forest species), 18 (create an outlet channel), 19 (create a storage wetland), and Measure 25 (install pump) were all dependent upon each other. These measures work together to create a system that delivers water from Chicken and Strong Ranch Sloughs, stores it in a wetland, discharges into Bushy Lake and eventually into the Lower American River through an outlet channel.

Some measures are not combinable. For example, if Measure 1 is applied at a site, then Measure 2 would not be applied at that same site, since these measures accomplish the same purpose of eradicating nonnative invasive plant species. The primary constraint in combining the flood plain measures at all four sites was the size of the land. Since, each site has a certain acreage, not all measures could be applied at their maximum scales. A list of combinable measures was developed and this data was input into the software program.

For the analysis of flood plain restoration measures, the software program ran all possible combinations. Cost effectiveness and incremental cost analyses were performed using the IWR-Plan software. This analysis was used to limit the number of ecosystem restoration plan

TABLE 6-1. Initial Screening–Ecosystem Restoration Measures–Urrutia Site

Measures	IWR Symbol	Cost					Benefits	
		First Cost/ Acre	Avg O&M Cost	AAEC/Acre	Acres	Annual Cost	AAHU Gain/Acre	Total AAHUs
Measure 1. Herbicide application and mechanical eradication of non-native invasive plant species	T	1,050	50	124	10	1,240		No Value (0)
Measure 7. Grade the floodplain terrace to restore appropriate hydrology to support riparian forest species	A	34,000	650	3,030	25	75,750	0.87	21.75
	B	34,000	650	3,030	45	136,350	0.87	39.15
	C	34,000	650	3,030	55	166,650	0.87	47.85
	D	34,000	650	3,030	65	196,950	0.87	56.55
Measure 8. Plant riparian oak woodland species	E	15,500	540	1,625	5	8,125	0.1	0.50
	F	15,500	540	1,625	11	17,875	0.1	1.10
Measure 10. Seed grassland	G	3,000	520	730	4	2,920	0.02	0.08
	H	3,000	520	730	7	5,110	0.02	0.14
	I	3,000	520	730	10	7,300	0.02	0.20
Measure 13. Modify hydrology and construct side-channels off the main American River channel and plant shallow aquatic, seasonal wetland, and riparian forest species	J	74,500	650	5,865	25	146,625	1.93	48.25
	K	74,500	650	5,865	30	175,950	1.93	57.90
Measure 15. Terrace steep, degraded riverbanks and plant with riparian forest species	L	133,000	650	9,960	2.5	24,900	2.06	5.15
	M	133,000	650	9,960	17	169,320	2.06	35.02
	N	133,000	650	9,960	21	209160	2.06	43.26
	O	133,000	650	9,960	25	249,000	2.06	51.50
Measure 17. Construct low-elevation bank benches in interior open waters and plant with emergent wetland species	P	20,500	520	1,955	2	3,910	0.26	0.52
	Q	20,500	520	1,955	4.5	8,798	0.26	1.17
	R	20,500	520	1,955	7	13,685	0.26	1.82
Measure 26. Purchase land	S	7,000		490	122.8	63,760		No Value
		400		28	128.2	3,590		(0)

AAEC = Average Annual Equivalent Cost
AAHUs = Average Annual Habitat Units
O&M = Operation and Maintenance

TABLE 6-2. Initial Screening–Ecosystem Restoration Measures–Woodlake Site

Measures	IWR Symbol	Cost					Benefits	
		First Cost/ Acre	Avg. O&M Cost	AAEC/Acre	Acres	Annual Cost	AAHU Gain/Acre	Total AAHUs
Measure 3. Excavate seed bank to remove non-native invasive plant species	Z	12,500	0	875	60	52,500		No Value (0)
Measure 7. Grade the floodplain terrace to restore appropriate hydrology to support riparian forest species	C	34,000	650	3,030	12	36,360	0.48	5.76
	D	34,000	650	3,030	10	30,300	0.48	4.80
	E	34,000	650	3,030	16	48,480	0.48	7.68
Measure 8. Plant riparian oak woodland species	G	15,500	540	1,625	10	16,250	0.23	2.30
	H	15,500	540	1,625	12	19,500	0.23	2.76
	I	15,500	540	1,625	14	22,750	0.23	3.22
	S	15,500	540	1,625	16	26,000	0.23	3.68
Measure 9. Plant oak savanna species	J	14,300	400	1401	15	21,015	0.21	3.15
	K	14,300	400	1401	20	28,020	0.21	4.20
	L	14,300	400	1401	25	35,025	0.21	5.25
Measure 10. Seed grassland	N	3,000	520	730	20	14,600	0.15	3.00
	O	3,000	520	730	35	25,550	0.15	5.25
	P	3,000	520	730	50	36,500	0.15	7.50
Measure 16. Restore connectivity between the river corridor and flood plain terrace by lowering berms	U	61,500	520	4,825	5.5[a]	4,825	0.88	4.84
Measure 26. Purchase land	F	1,000		70	283	19,810		No Value (0)

[a] 1 acre of cost = 5.5 acres of benefit

[b] 2 acres of cost = 8.5 acres of benefit

AAEC = Average Annual Equivalent Cost

AAHUs = Average Annual Habitat Units

O&M = Operation and Maintenance

TABLE 6-3. Initial Screening–Ecosystem Restoration Measures–Bushy Lake Site

Measures	IWR Symbol	Cost					Benefits	
		First Cost/ Acre	Avg. O&M/ Acre	AAEC/Acre	Acres	Annual Cost	AAHU Gain/Acre	Total AAHUs
Measure 1. Herbicide application and mechanical removal of non-native invasive plant species	S2	1,050	50	124	20	2,480		No Value (0)
Measure 3. Excavate seed bank to remove non-native invasive plant species	S3	12,500	0	875	20	17,500		No Value (0)
Measure 5. Grade floodplain terrace to support seasonal wetlands and plant native wetland plant species	A	33,000	390	2,700	12	32,400	1.25	15.0
	B	33,000	390	2,700	15	40,500	1.25	18.75
	C	33,000	390	2,700	18	48,600	1.25	22.5
Measure 7. Grade the floodplain terrace to restore appropriate hydrology to support riparian forest species and plant native riparian forest species	F	34,000	650	3,030	14	42,420	0.58	8.12
	D	34,000	650	3,030	17	51,510	0.58	9.86
	E	34,000	650	3,030	20	60,600	0.58	11.6
Measure 9. Plant oak savanna species	I	14,300	400	1,401	50	70,050	0.26	13.01
	J	14,300	400	1,401	60	84,060	0.26	5.61
	K	14,300	400	1,401	70	98,070	0.26	8.2
Measure 13. Modify hydrology and construct side-channels off the main American River channel and plant shallow aquatic, seasonal wetlands, and riparian forest species	P	74,500	650	5,865	3	17,595	1.87	5.61
	Q	74,500	650	5,865	3.75	21,994	1.87	7.01
	Y	74,500	650	5,865	4.5	26,393	1.87	8.42
Measure 15. Terrace steep, degraded riverbanks and plant with riparian forest species	N	133,000	650	9,960	4	39,840	1.88	7.52
	O	133,000	650	9,960	6	59,760	1.88	11.28
	T	133,000	650	9,960	8	79,680	1.88	15.04
Measure 18. Create outlet stream channel from Bushy Lake to the American River and plant with riparian and wetland vegetation	V	33,000	390	2,700	1.5	4,050	0.35	0.53
	R	33,000	390	2,700	1.75	4,725	0.35	0.61
	W	33,000	390	2,700	2.0	5,400	0.35	0.7
Measure 19. Diversion of stormwater flows above 2 cfs to Bushy Lake	U	64,161	3,208	7,699	6	46,194	0.37	2.22
Measure 25. Install pump to convey stormwater flows to created wetlands, Bushy Lake, and the American River	X	304,693	8,200	29,529		29,529		No Value (0)
Measure 26. Purchase land	S1	1,000	0	70	337	23,590		No Value (0)

AAEC = Average Annual Equivalent Cost
AAHUs = Average Annual Habitat Units
O&M = Operation and Maintenance

TABLE 6-4. Initial Screening–Ecosystem Restoration Measures–Arden Bar Site

Measures	IWR Symbol	Cost					Benefits	
		First Cost/ Acre	Avg. O&M Cost	AAEC/Acre	Acres	Annual Cost	AAHU Gain/Acre	Total AAHUs
Measure 1. Herbicide application and mechanical eradication of non-native invasive plant species	A	1,050	50	124	110	13,640		
Measure 7. Grade the floodplain terrace to restore appropriate hydrology to support riparian forest species	B	34,000	650	3,030	5	15,150	0.58	2.90
	C	34,000	650	3,030	8	24,240	0.58	4.64
	D	34,000	650	3,030	21	63,630	0.58	12.18
	E	34,000	650	3,030	26	78,780	0.58	15.08
	F	34,000	650	3,030	31	93,930	0.58	17.98
Measure 9. Plant oak savanna species	J	14,300	400	1,401	1.5	2,101	0.28	0.42
	K	14,300	400	1,401	8	11,208	0.28	2.24
	M	14,300	400	1,401	1925	26,619	0.28	5.32
	N	14,300	400	1,401		35,025	0.28	7.00
Measure 14. Construct a high-flow bypass channel	O	73,500	500	5,645	7	39,515	0.45	3.15
Measure 17. Construct low-elevation bank benches in interior open waters and plant with emergent wetland species	P	20,500	520	1,955	0.5	978	0.33	0.17
	Q	20,500	520	1,955	1	1,955	0.33	0.33
	R	20,500	520	1,955	1.5	2,933	0.33	0.50
Measure 21. Fill and plant with native riparian oak woodland species	S	53,000	540	4,250	2	8,500	0.3	0.60
	T	53,000	540	4,250	3.5	14,875	0.3	1.05
Measure 22. Plant banks of proposed high-flow bypass channel with willow species	U	2,500	390	565	4.5	2,543	0.55	2.48
Measure 23. Create shallow aquatic habitat at the outlet of the proposed high-flow bypass channel to create permanent lentic habitat for native fish species	V	67,500	390	5,115	0.5	2,558	0.77	0.39
	W	67,500	390	5,115	0.75	3,836	0.77	0.58
Measure 24. Remove levee from around Sheriff's Training Facility and reuse or dispose of material	X	77,000	0	5,390	9	48,510		No Value (0)
Measure 26. Purchase land	Y	400	0	28	280	7,840		No Value (0)

AAEC = Average Annual Equivalent Cost
AAHU = Average Annual Habitat Unit
O&M = Operation and Maintenance

alternatives. CE/ICA analysis identifies the least-cost solutions for each level of output. The three criteria used for identifying non-cost effective plans or combinations include: (1) the same level of output could be produced by another plan at less cost; (2) a larger output level could be produced at the same cost; or (3) a larger output level could be produced at least cost. The number of cost effective combinations ranged from 13 at Bushy Lake to 165 at Urrutia.

Incremental cost is the change in cost that results from a decision. Incremental cost analysis compares the incremental costs for each additional unit of output. This is not the average cost per output. The first step in developing the best buy plans is to determine the incremental cost per unit. The plan with the lowest incremental cost per unit over the no-action plan is the first incremental best buy plan. Plans that have a higher incremental cost per unit for a lower level of output are eliminated. The next step is to recalculate the incremental cost per unit for the remaining plans. This process is reiterated until the lowest incremental cost per unit for the next level of output is calculated. The intent of the incremental analysis is to identify large increases in cost relative to output.

The total number of flood plain best buy plan alternatives determined at each site range from one plan at Woodlake to six plans at Urrutia. The Best Buy alternatives for each site are summarized in Tables 6-5 through 6-8.

The cost effectiveness and incremental cost analyses indicated that there is only one best buy plan for the Woodlake site. An iterative process was used to evaluate the single best buy plan with other identified cost effective plans that produce smaller output levels at lower costs, as shown on the following graphic depiction of results. The purpose of this process was to look for significant increases in production costs as output levels increased to determine whether or not the single best buy plan, in fact, optimizes benefits. While a cost effective plan was identified, the study team determined that the best buy plan alternative is most desirable because of the higher amount of AAHUs and related native grasslands, riparian forest, oak woodland, and oak savanna habitat created; habitat types that are extremely limited within the local and regional context.

The selected Urrutia and Arden Bar restoration plan alternatives were chosen based on the identification of a sharp breakpoint in the incremental cost graph between the selected best buy plan and the next largest best buy plan. In contrast, the selected Bushy Lake and Woodlake restoration plan alternatives were chosen because the incremental cost graph was proportionately increased between best buy plans and resulted in the selection of only one best buy plan out of a full range of combinations of measures, respectively. Therefore, the selected Bushy Lake and Woodlake restoration plans were chosen to maximize the desired output. All of these restoration plans were also selected because implementation would effectively remove the nonnative invasive plant species that pervade in favor of the re-establishment of native riparian and wetland plant communities.

TABLE 6-5. Initial Alternatives (Best Buy Plans for Urrutia)

Plan No.	Measures in the Plan	Increm. Annual Cost/AAHU	Increm Output (AAHU)	Increm. Cost	Total Annual Cost	Total AAHUs	Average Annual Cost/ AAHUs	Total First Cost
1	Grade/plant riparian forest- 55 acres; Create side channels-30 acres; Purchase Land; Herbicide/Mechanical removal of non-native invasive plant species-10 acres	$3,815	105.75	$403,402	$403,402	105.75	$3,814	$6,613,934
2	Grade/plant riparian species-55 acres; Create side channels -30 acres; Terrace Steep Banks -21 acres; Purchase Land; Herbicide/Mechanical removal of non-native invasive plant species-10 acres	$4,733	43.26	$204,750	$608,152	149.01	$4,733	$10,397,032
3	Grade/plant riparian species-55 acres; Create side channels -30 acres; Terrace Steep Banks -21 acres; Construct low level bank benches- 2 acres; Purchase Land; Herbicide/Mechanical removal of non-native invasive plant species-10 acres	$7,519	0.52	$3,910	$612,062	149.53	$4,093	$10,453,847
4	Grade/plant riparian species-55 acres; Create side channels -30 acres; Terrace Steep Banks -21 acres; Construct low level bank benches- 4.5 acres; Purchase Land; Herbicide/Mechanical removal of non-native invasive plant species-10 acres	$7,520	0.65	$4,888	$616,950	150.18	$4,108	$10,524,867
5	Grade/plant riparian species-55 acres; Plant Riparian Oak Woodland-11 acres; Create side channels -30 acres; Terrace Steep Banks -21 acres; Construct low level bank benches- 4.5 acres; Purchase Land; Herbicide/Mechanical removal of non-native invasive plant species-10 acres	$16,102	1.1	$17,875	$634,825	151.28	$4,196	$10,761,137
6	Grade/plant riparian species-55 acres; Plant Riparian Oak Woodland-11 acres; Create side channels -30 acres; Terrace Steep Banks -21 acres; Seed Grassland - 10 acres; Construct low level bank benches- 4.5 acres; Purchase Land; Herbicide/Mechanical removal of non-native invasive plant species-10 acres	$36,500	0.2	$7,300	$642,125	151.48	$4,239	$10,802,710

TABLE 6-6. Initial Alternatives (Best Buy Plans for Woodlake)

Plan No.	Measures in the Plan	Increm. Cost/AAHU	Increm. Output (AAHU's)	Increm. Cost	Tot. Annual Cost	Total AAHU's	Average Annual Cost $/AAHU	First Cost
1	Purchase Land – 284 acres; Eradication of Non-native Invasive Plant Species-60 acres; Seed Grassland - 50 acres; Restore Connectivity- 5.5 acres; Plant Riparian Forest-16 acres; Plant Oak Woodland – 16 acres; Plant Oak Savanna – 25 acres	$7,645	28.95	$296,000	$296,000	28.95	$7,645	$3,560,000

TABLE 6-7. Initial Alternatives (Best Buy Plans for Bushy Lake)

Plan No.	Measures in the Plan	Increm. Cost/AAHU	Increm. Output (AAHU's)	Increm. Cost $	Tot. Annual Cost	Total AAHU's	Average Annual Cost $/AAHU	Total First Cost
1	Purchase Land-337 acres; Herbicide/Mechanical Removal of Non-native Invasive Species-20 acres; Excavate Seed Bank -20 acres; Grade/Plant Riparian Forest-17 acres; Construct Side Channel-3.75 acres; Grade Floodplain for Seasonal Wetlands-18 acres; Construct Outflow Channel -1.75 acres; Install Pump and Delivery System; Construct Storage Wetland-6 acres	$4,858	42.2	$205,022	$205,022	42.2	$4,858	$4,509,543
2	Purchase Land-337 acres; Herbicide/Mechanical Removal of Non-native Invasive Species-20 acres; Excavate Seed Bank -20 acres; Grade/Plant Riparian Forest-17 acres; Construct Side Channel-3.75 acres; Grade Floodplain for Seasonal Wetlands-18 acres; Terrace Steep Banks/Plant Riparian-8 acres; Construct Outflow Channel-1.75 acres; Install Pump and Delivery System; Construct Storage Wetland -6 acres	$5,037	15.04	$75,760	$280,782	57.24	$5,037	$6,101,597
3	Purchase Land-337 acres; Herbicide/Mechanical Removal of Non-native Invasive Species-20 acres; Excavate Seed Bank –20 acres; Grade/Plant Riparian Forest-17 acres; Construct Side Channel-3.75 acres; Grade Floodplain for Seasonal Wetlands-18 acres; Terrace Steep Banks/Plant Riparian-8 acres; Construct Outflow Channel-1.75 acres; Install Pump and Delivery System; Plant Oak Savanna-70 acres; Construct Storage Wetland 6 acres	$5,388	18.2	$192,218	$473,000	75.44	$5,022	$7,540,000

TABLE 6-8. Initial Alternatives (Best Buy Plans for Arden Bar)

Plan No.	Measures in the Plan	Increm. Cost/AAHU	Increm. Output (AAHU's)	Increm. Cost $	Total Annual Cost	Total AAHU's	Average Annual Cost $/AAHU	Total First Cost
1	Purchase Land-280 acres; Eradicate non-native plant species-110 acres; Grade/Plant Riparian Forest-31 acres; Plant Oak Savanna-19 acres; Construct low level bank benches-0.5 acre	$8,210	25.48	$209,198	$209,198	25.48	$8,210	$2,151,755
2	Purchase Land-280 acres; Eradicate non-native plant species-110 acres; Grade/Plant Riparian Forest-31 acres; Plant Oak Savanna-19 acres; Construct low level bank benches-1.5 acre	$8,992	3.31	$29,764	$238,961	28.79	$8,300	$2,123,347
3	Purchase Land-280 acres; Eradicate non-native plant species-110 acres; Grade/Plant Riparian Forest-26 acres; Plant Oak Savanna-25 acres; Construct low level bank benches-1.5 acre; Construct high-flow bypass channel-7 acres; Plant banks of bypass channel-4.5 acres; Create lentic habitat at bypass channel outlet-0.75 acre	$14,400	0.60	$8,640	$247,601	29.39	$8,425	$2,833,786

Flood Plain Measures Not Evaluated Using Incremental Analysis

Some flood plain measures were not evaluated using the incremental analysis program, because they could not be evaluated using the HEP evaluation procedure. Therefore, these measures did not have any intrinsic HEP value or quantifiable benefits. However, the purchase of land measure (Measure 26) and the eradication of nonnative invasive plant species measures (Measures 1 and 3) were included in the incremental analysis by making all other measures dependent upon these two measures and assigning costs only input to the IWR-Plan program. The following measures were eliminated from further consideration during the initial screening of measures:

Measure 2. Control of nonnative invasive plant species through burning. This measure was not assigned a HEP value and implementation would be very difficult because of local and regional air quality control permitting requirements.

Measure 11. Provide downed, large woody material to construct brush piles. This measure was not assigned a HEP value based on the Habitat Suitability Index (HSI) model that was used to evaluate restoration measures.

Measure 12. Manage grassland as hay crop for raptor forage. This measure was screened out during the evaluation of measures because it was determined to be a land management measure rather than a site restoration measure.

6.2 Fisheries Restoration

6.2.1 Fisheries Plan Formulation Process

Under Corps guidelines, the purpose of ecosystem restoration is to restore significant ecosystem function, structure, and dynamic processes that have been degraded. The intent of restoration is to reestablish the attributes of a functioning, and self-regulating system. The formulation of this plan focuses on this stated purpose and intent. The project team evaluated several different measures for reconfiguring current structures or implementing the construction of new structures to facilitate optimum management of water temperature in the Lower American River. These measures are outlined in detail in Appendix A, Attachment 5; a recommended fisheries ecosystem restoration measure was advanced for this analysis.

6.2.2 Fisheries Goals and Objectives

Planning goals and objectives were developed to address the identified problems and opportunities for improving fisheries and aquatic habitat in the Lower American River.

6.2.3 Fisheries Goals

The FISH Working Group, one of the four working groups of the Lower American River Task Force, commissioned the preparation of a report, the Baseline Report, outlining baseline conditions within the Lower American River with respect to aquatic habitat. The Baseline Report provided the basis for prioritizing opportunities for restoration of aquatic habitat in the

Lower American River. The Baseline Report established that flow and temperature improvements have the greatest potential for restoration with respect to the fish of primary management concern. As a result, the most immediate opportunities that exist for fish habitat improvement involve dam operations and management actions. Manipulating the timing, temperature, and rate of flow released from Folsom and Nimbus Dams is likely to produce the most immediate and effective results for fish restoration (Surface Water Resources 2001a).

An adequate flow and water temperature regime is essential to create favorable conditions for Lower American River salmonids. Streamflow patterns are important in maintaining geomorphology of watersheds such as meander belts and stream channel configuration, as well as riparian and flood plain vegetation along stream banks. Streamflow influences the well-being of valley wetlands, riparian communities, and the habitat of fish and other aquatic organisms. Streamflow also is essential for the well-being of native resident fish, including anadromous salmonids. Sufficient flows are necessary for anadromous salmonid adult migration, spawning, egg incubation, and juvenile rearing and emigration especially because these functions must now occur in the lowermost 23 miles of the American River below Nimbus Dam. In some cases, flows exceeding natural, unimpaired river flows below Nimbus Dam are recommended because anadromous salmonids must conduct these functions in the nontraditional habitats of the lower river instead of the upstream reaches above Folsom Dam (Surface Water Resources 2001a).

Of all limiting factors and potential corrective actions, maintaining suitable water temperatures and instream flows would be more beneficial for salmonid production in the Lower American River than all other actions combined. Flow standards are currently under development by the Water Forum. Therefore, building on the baseline conditions and prioritization summarized in the Baseline Report prepared for the FISH Working Group, the following goals have been established for the management and restoration of water temperature in the Lower American River below Nimbus Dam:

- **Goal 1:** Reduce water temperature in the Lower American River during critical stages in the life cycles of Sacramento River fall/late fall-run chinook salmon and Central Valley steelhead so as to increase the number of these fish spawning naturally in the river.

- **Goal 2:** To the greatest extent possible, reach those temperatures recommended by the California Department of Fish and Game (DFG) for Central Valley steelhead and Sacramento River fall/late fall–run chinook salmon (i.e., 56°F between October 1 and June 30 and between 56 and 60°F for July 1–September 30).

- **Goal 3:** Significantly increase the Central Valley steelhead and Sacramento River fall/late fall–run chinook salmon natural production fish populations in the Lower American River. This goal is in line with the policy of the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 to double the natural production of salmon and steelhead by the end of the last century.

6.2.4 Fisheries Objectives

Based on the aforementioned goals, objectives were developed to complement and provide focus to these goals. Some objectives are applicable to more than one goal. All are in-stream temperature related.

Objective 1: Improve Adult Migration

Elevated temperatures in late summer and early fall in the Lower American River (sometimes extending well into October) often exceed 65ºF. Relatively high water temperatures delay the onset of adult fall-run chinook salmon spawning and impede reproductive success. Exposure of prespawning adult chinook salmon to relatively high water temperatures can result in increased prespawning mortality, reduced gamete production, infertility, and an increase in embryonic developmental abnormalities.

Objective 2: Increase Spawning Habitat

Chinook salmon spawning is concentrated in several well-documented areas in the river, primarily between RM 14 and 22. During low-flow conditions and high-temperature conditions, the extent of available spawning habitat is further restricted. Adult fall-run chinook salmon generally do not initiate spawning in the Lower American River until water temperatures decrease to approximately 60°F.

Objective 3: Reduce Egg Mortality

Constant exposure of salmonid eggs to temperatures above 56°F will result in some egg mortality, and incubation at constant water temperatures above 63°F is believed to result in complete egg mortality. Temperatures above 56ºF can occur when eggs and alevins are incubating in the Lower American River. This problem is most likely to occur for chinook salmon in October and November.

Objective 4: Improve Rearing Habitat and Juvenile Outmigration

The availability of rearing habitat is directly related to flow; however, physical habitat availability considerations are probably overridden by water temperature concerns during late spring, summer, and early fall. In addition to direct thermal stress, elevated temperatures during rearing and outmigration of the chinook salmon and steelhead can result in multiple indirect effects, including increased risk of predation, decreased growth rates, starvation, and susceptibility to disease, which contribute to reduced juvenile survival. Thermal stress to juvenile steelhead is a particular problem from July through October, when water temperatures at Watt Avenue frequently exceed 65°F.

6.2.5 Fisheries Restoration Planning Constraints and Criteria

Overall Constraints

Consideration was given to several planning constraints during development of the goals, objectives, and measures:

- Proposed restoration activities should be consistent with the RCMP.
- Existing high-quality wildlife habitat, fisheries habitat, and native plant communities should not be disturbed by restoration activities.
- American River Parkway recreation activities should be maintained.
- Existing major utility, gas, sewer, cable, and telephone infrastructure should remain in place with existing access maintained.
- The flood capacity of the floodway should be maintained.
- Proposed restoration activities should be self-sustaining, requiring little long-term maintenance.
- Generation of hydroelectric power at Folsom Dam water supply should be maintained.
- Boating and other recreation on Folsom Reservoir and Lake Natoma should be maintained.

The following section evaluates measures that could be implemented to achieve the aforementioned goal and objectives, while considering the planning criteria and constraints.

Site Specific Constraints

Additional site-specific constraints were also addressed including:

- cost,
- ease of operation,
- flexibility,
- reliability,
- construction schedule, and

- environmental impacts during construction.

Criteria

The structural and operational temperature reduction techniques were screened to identify a preferred temperature restoration measure. The screening criteria used for this analysis include:

- **Effectiveness:** The extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities. An effective plan is responsive to the wants and needs of people and makes a significant contribution to the solution of some problem. Measures that make a significant contribution to the planning goals were advanced.

- **Efficiency:** The extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment. Efficiency measures not only evaluate dollar costs, but also whether other resources are used efficiently in the construction and implementation of a plan; this is represented as "cost-effectiveness." Only cost-effective measures were advanced.

- **Acceptability:** The workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies. The two primary components of acceptability include implementability, including technological, environmental, economic, and social feasibility, and satisfaction. Measures that were readily implementable and satisfactory to the Corps, Bureau, and FISH Work Group were advanced.

- **Completeness:** The extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. Measures that were well thought out and whose implementation actions are accounted for in context of all investments and actions were advanced.

Benefit Evaluation

HEP Evaluation

The HEP methodology that was used to evaluate the floodplain sites was modified to determine the total AAHUs related to automation of the temperature control shutters at Folsom Dam. An assumption that the shutter automation would be 5 to 8 times more effective per acre than the four floodplain restoration sites in creating new habitat value was used to determine what the Service considers to be a conservative estimate HSI of 0.7. This conversion factor was applied to the downstream river channel area to determine total AAHUs. This index represents the increase in habitat value for anadromous salmonids that are Federally listed

and, therefore, afforded additional protection under the Endangered Species Act to assist the long-term survival of the species.

Fisheries Restoration Measure

Background

At certain times, high water temperatures are a serious limiting factor affecting the reproduction, growth and survival of anadromous salmonids in the Lower American River. Historically, this is not thought to have been a problem. Before the modern era of dams and development on the American River, adult salmonids returning to the river to spawn were transiently and periodically exposed to warm water temperatures in the Sacramento-San Joaquin Delta, lower Sacramento River, and Lower American River. However, upon their ascent to over 100 miles of upstream historic spawning and rearing reaches above where Folsom Dam is now sited, perennially cooler water temperatures were encountered and water temperatures were likely rarely, if ever, an important population-limiting factor. Moreover, most downstream movements of juvenile salmonids are believed to have historically occurred during spring and early summer, when Lower American River flows were high and cool due to runoff from the melting snowpack in the nearby Sierra Nevada Mountains.

Under present conditions and with existing facilities, including Folsom and Nimbus dams, salmonid life cycles have been artificially restricted to existing conditions in the Lower American River. Releases of coldwater (resulting from seasonal stratification of Folsom reservoir) to the river in the optimal temperature ranges for salmon and steelhead depend on many variables. However, frequently such coldwater is often either in low supply or completely unavailable for anadromous fishery needs.

The two most common adverse biological impacts are: (1) exposure of pre-spawning adult salmon to elevated water temperatures in the fall; and (2) exposure of juvenile steelhead to elevated water temperatures during the spring through early fall, particularly during hot summer periods with maximum solar radiation. Such impacts do at times, depending on the severity and duration of the elevated water temperatures, become population-limiting factors for Lower American River anadromous salmonids.

Maintenance of optimal water temperatures for salmonids in the Lower American River depends on the ability to deliver coldwater releases to the river from Folsom Dam and hence through Nimbus Dam. This in turn is limited by: (1) the volume of the coldwater pool available behind the dams (mainly behind Folsom Dam); and (2) the ability to physically access this coldwater and deliver it downstream as needed to promote suitable aquatic habitat for downstream fisheries.

Water Temperature Objectives

Currently, reservoir release operations follow an iterative process referred to as the Automated Temperature Selection Procedure (ATSP) in which target water temperatures, as measured in the river flow at Watt Avenue, are achieved by drawing release water from specific reservoir levels. The most preferred (and realistically achievable) Schedule 1 water temperatures

at Watt Avenue which would have the lowest impacts to salmonids are: 56°F during May; 56.5°F during June; 65°F during July-September; 57°F during October; and 55°F during November. River water temperatures are not considered to be a problem during the remaining months (December-April) when abundant seasonal coldwater is available for release from the reservoirs.

Under the ATSP process, when the Schedule 1 temperatures cannot be met, a Schedule 2 temperature regime, which is only slightly more detrimental to salmonids, is attempted. When Schedule 2 temperatures cannot be met, the process continues cycling downward through a series of 48 total schedules to the next slightly more detrimental temperature regime for the critical (spring-fall) months. This continues until a schedule of temperature targets, which is considered the least detrimental (to salmonids) regime feasible under existing conditions (i.e., current reservoir storage, available coldwater pool, Delta inflow needs, air temperatures, and other determinants) can be met for the year. In many years, including in 2001, coldwater is either already limited or depleted early in the critical period, thus a temperature target schedule highly detrimental to salmonids must be adopted.

In addition to the ATSP, National Marine Fisheries Service has issued an interim Biological Opinion for Central Valley Project operations that includes an objective to not exceed a mid-day water temperature of 65°F in the Lower American River at Watt Avenue throughout the year. This criterion is for the preservation of juvenile steelhead rearing habitat. Excessive water temperatures are considered to be the most significant stressor affecting juvenile steelhead in the river. Juvenile steelhead remain in the river throughout the year, whereas juvenile salmon emigrate from the river within at most a few months after hatching. Low over-summer survival of steelhead is believed to be the cause of the apparent low numbers of naturally-spawned steelhead that return annually to the river. Most of the river's returning steelhead are of hatchery origin.

Fisheries Habitat Problems and Excessive Water Temperatures

The detriments of excessive water temperatures to salmonids can be in the form of direct mortality to adults, juveniles, and eggs when temperature thresholds are greatly exceeded and/or exceeded for extended periods. In addition, a number of chronic, sub-lethal and indirect effects of high water temperatures, which are nevertheless sometimes population-limiting factors, are experienced which include the following:

- Causing smaller fry to be produced, which have lower survival due to increased vulnerability to predation, reduced overwinter survival, and alterations of their downstream migration timing;

- Causing poor body condition, which increases susceptibility to predation and diseases;

- Increasing food requirements and thus intra- and inter-specific competition for available feeding stations and food supplies;

- Causing premature seaward migration from the river, which causes fish to be ill-prepared physiologically to survive in a saline environment;

- Delaying the onset of salmon spawning in the fall, causing reduced egg production and fertility, greater egg retention, and increased embryonic abnormalities, in addition to the direct pre-spawning mortality of the returning adults; and

- Crowding spawning salmon into the uppermost Lower American River reaches where water is the coolest, causing spawning nest (redd) superimposition, which also reduces productivity.

Evaluation of Water Temperature Measures

Recently, several structural and operational measures have been identified and preliminarily evaluated for their utility to help alleviate Lower American River water temperature problems for salmonids. Two broad approaches examined were: (a) increasing coldwater pool volumes behind the two dams and/or (b) improving access to and delivery of such water to the river (U.S. Bureau of Reclamation 2001).

In January 2001, the Folsom Lake and Headwaters working group provided the following 15 structural, 8 operational, and 1 combination measure for consideration as alternative temperature reduction measures:

- modernizing the shutters to a 7(1)-2 configuration,

- installing temperature curtains at tributary inflows,

- installing or using low-level outlet works to generate power and access the coldest water in the lake,

- constructing a cold-water isolation/pump back system to exchange water between Lake Natoma and Folsom Reservoir,

- retrofitting the shutters with an “elephant trunk” that delivers cold water to the penstock,

- improving the short-term management of shutter operation,

- conducting additional temperature monitoring,

- purchasing water from upstream reservoirs to increase the supply of cold water in Folsom Reservoir,

- normalizing gate operations (to mimic natural hydrology), and

- bypassing the turbines and releasing directly from the low-level outlet works.

The Lake Natoma/Nimbus Dam work group provided the following structural measures to reduce water temperatures in the Lower American River:

- installing temperature curtains (either at the plunge zone of Lake Natoma or at the Nimbus Power Plant intake),
- removing all, or part of, the submerged concrete debris wall in front of the Nimbus Power Plant,
- constructing a temperature control device for Nimbus Dam Spillway Bay(s),
- modifying the channel in Lake Natoma,
- installing a pipe from Folsom Tailrace to Nimbus outlet,
- moving Natoma Power Plant and outlet to the opposite side of Lake Natoma with a temperature control device, and
- placing a coldwater barrier in front of Folsom South Canal.

The Nimbus Hatchery and Open Lower American River work group provided the following structural and operational measures to enhance fish habitat:

- building instream habitat improvement projects downstream of Nimbus Dam,
- developing access for steelhead above Folsom Dam,
- building off-site habitat downstream of Nimbus Dam for steelhead,
- real-time temperature monitoring,
- diverting flows from Folsom South Canal into the Cosumnes River,
- performing a quick evaluation of current operations, and
- coordinating techniques and tools to optimize use of cold water.

Of the structural and operational measures examined, the one with the most promise and ultimately selected as the preferred plan alternative is a structural measure involving modernization of the water outlet (temperature control) shutters of Folsom Dam. Folsom Dam

shutter modernization is being considered an ecosystem restoration measure for evaluation because of its potential to help restore historical water temperature regimes needed to maximize the Lower American River's natural in-river anadromous salmonid production. As described above, these historical water conditions are no longer available to the river's fisheries.

The operation of and present problems with Folsom Dam's temperature control shutters have recently been described in detail by Surface Water Resources, Inc. (SWRI) (2001a, 2001b), the Bureau (2001), and HDR Engineering (2001).

Existing Shutter Operations Problems

Folsom Dam's temperature control shutters are a series of large, solid metal plates or panels within metal tracks which can be lowered or raised to allow reservoir water to enter the three penstocks leading to the dam's power-generating turbines. After passing the turbines, the water empties into the Lower American River.

Each of the three power penstock intakes on the dam is enclosed in a housing that supports a set of 45 removable 13-foot high shutter panels. Each group of 45 shutters is arranged in 5 vertical columns of 9 panels each. A varying number of shutters can be lifted up to draw water from various elevations within the reservoir, thereby controlling the temperature of water entering the Lower American River.

However, presently, there is no capability to raise each of the 45 shutters individually and independently. Instead, shutters are bolted together such that the nine shutters comprising each vertical column have a 3-2-4 configuration. This means that the top three panels are bolted together and are raised as a unit, followed by the next two panels as a unit, and the last four panels as a unit. This configuration allows for reservoir water to be drawn into the penstocks from four distinct elevation ranges (i.e., with no panel, lowest panels, two lowest panels, or all three panels [shutter groups] in place.)

The present 3-2-4 shutter configuration and operations (for controlling temperatures) have a number of drawbacks and problems that are ultimately detrimental to the river's salmonid fisheries as follows:

- Each shutter change is labor intensive, requiring a three-person crew for completion. Often, because of scheduling conflicts with other duties of the crew, needed temperature changes are either delayed or foregone completely;

- Each shutter change is time-consuming, requiring 8-12 hours, sometimes spread over a 2-day period, which further delays a responsive implementation of needed changes;

- Each shutter change causes traffic delays and stoppage across the Folsom Dam Road, a heavily traveled corridor. As a result, there is often pressure on operators to delay or forego changes.

- Due to the various constraints, usually only about 3-5 shutter modifications can actually be made each critical season, whereas optimal temperature management for salmonid benefits might necessitate some multiple of this number;

- Some amount (as yet unquantified) of coldwater is believed to be lost annually from leakage occurring at or around the existing shutters and their related structural features. This is coldwater that could otherwise be available for fisheries maintenance.

- Each shutter change is at best a rather coarse action, which means that often, much more coldwater must be released to achieve a particular temperature objective than would be necessary with a more efficient, high-operational-flexibility system. Again, this results in wasted coldwater that could otherwise benefit salmonids later in the same critical season. The inefficiency clearly results in some subsequent within-season temperature objectives failing to be met. In addition, the present system results in frequent severe temperature "spikes" both upwards and downwards, which may be a detrimental impact to fish and/or the river's aquatic food base.

Measures Evaluated

As set forth in Appendix A, Attachment 5, a series of temperature reduction measures was evaluated. These measures were identified during a three-day Folsom Dam temperature management conference sponsored by the Bureau in January 2001. Based on this evaluation, reconfiguration and modernization of the dam's temperature shutter system were selected as the most effective measures. Measure 1 calls for modifying the shutter housings to allow each of the top seven shutters to be raised and lowered individually. Because of flow limitations into the penstocks, each of the bottom two shutters would be operated as a single unit. The resulting new shutter configuration would thus be 1-1-1-1-1-1-1-2, or 7(1)-2, compared to the current 3-2-4 configuration. The new configuration would provide the greatest possible operational flexibility using the existing shutters, allowing the reservoir withdrawals to occur at 13-foot intervals. This would create essentially the same operational flexibility as a truly unlimited shutter-positioning scheme.

The 7(1)-2 project could be built for either manual or automated operation. Although the automated system would have considerably higher construction cost, the manual operation was determined to be infeasible because of structural, operational, and institutional constraints (HDR Engineering 2001, Jones & Stokes 2001b).

Measure 2 involves the same kind of shutter housing modifications, except that a less flexible 1-1-2-2-3 configuration would be created. The 1-1-2-2-3 configuration has been proposed as mitigation for the long-term reoperation of Folsom Reservoir and thus constitutes the future without project condition. This configuration would allow for selection of six different release elevations instead of the present four. Operation would continue to be manual. While greater operational flexibility would be achieved, it would be much less flexible than Measure 1.

Salmon Mortality Modeling Results. SWRI (2001a) used a combination of existing Lower American River modeling tools, with appropriate modifications, to derive estimates of the annual mortality to early-life-stage chinook salmon that would occur under various shutter configurations (see SWRI 2001a for detail). The models that SWRI (2001a) used produced outputs suitable only for comparative planning purposes, and not for predicting actual in-river conditions at specific times and locations. Thus, these salmon mortality data are not definitive absolute values, but merely broad indicators providing "reasonable detection limits" of changes and general ranges that would be expected.

Only salmon mortality results were derived because a similar model of steelhead mortality was not available. However, SWRI's (2001a) modeling analyses were completed in a manner assuming the "best" year around balanced water temperature conditions for both salmon and steelhead. Thus, benefits for salmon often equate with benefits for steelhead. Otherwise, a planning effort (for water temperatures) directed only at the summer needs of juvenile steelhead would often result in severely depleted coldwater reserves needed by fall-spawning adult salmon. Conversely, planning aimed at the water temperature needs of fall salmon would often result in severe impacts to juvenile steelhead during summer.

SWRI's (2001a) salmon mortality data (Table 6-9) were used in concert with other qualitative results and findings they presented to derive a Habitat Suitability Index (HIS) for use here in the HEP application. HSIs for the HEP were derived using the model presented below. SWRI's (2001a) mortality estimates for salmon (Table 6-9) are given for only three "representative" water year-types: "favorable," "moderate," and "adverse" in which the modeled ATSP temperature schedules would generally correspond with favorable, moderate, and adverse temperature regimes for salmonids during the critical spring-fall period. In assigning HSIs using the word model presented below, it was assumed that each of these three year-type classifications used by SWRI (2001a) occurred in roughly one-third of all water years.

TABLE 6-9. Estimated (from Modeling) Annual Early-Life-Stage Salmon Mortality (%) in Relation to Various Water Temperature Shutter Control Configurations and Methods at Folsom Dam, by General Water Year-Type

General Water Year-Type	Shutter Configuration And Operation Mode			
	Existing (Man.) 3-2-4	**Projected (Man.) 1-1-2-2-3**	**Modernized (Man.) 7(1)-2**	**Modernized (Auto.) 7(1)-2**
Favorable	14.3	8.7	5.9	5.2
Moderate	10.1	11.9	6.1	6.6
Adverse (Drought)	16.2	20.0	13.6	9.0

Source: Surface Water Resources, Inc. 2001a.

HEP Results

The aquatic habitat that would be affected by the shutter reconfiguration measures was assumed to be the Lower American River from Nimbus Dam downstream 13 miles to Watt Avenue. Watt Avenue was the reference point for the SWRI (2001a) modeling effort. This reference point was previously selected by the NMFS in its biological opinion on interim operations of the CVP and SWP on Federally-listed threatened Central Valley spring-run

chinook salmon and threatened Central Valley steelhead as part of the Bureau consultation under Section 7 of the Federal Endangered Species Act. First, based on data in SWRI (2001b), it was determined that the mean monthly post-1956 (Folsom and Nimbus Dams completed) flow in the Lower American River for the critical temperature control months of April-November is about 2,600 cfs. Next, based on a systematic sample of 25 river surface-width cross sections measured from aerial photographs of the river taken at a flow of about 3,000 cfs, it was determined that the average April-November river width in the Nimbus-Watt Avenue reach is about 286 feet. Multiplying the average reach width by its length yields a riverine surface area estimate of 451 acres during the annual critical period. This is the value used in the HEP. The HEP analysis completed for the temperature control shutter alternative indicates that juvenile steelhead would be the primary beneficiaries of temperature improvements, but little is known within the scientific community about habitat preferences of juvenile steelhead within the Lower American River. To be conservative in describing benefits to this species, the HEP used the whole surface area of the river downstream from the dam to Watt Avenue. While acknowledging that juvenile steelhead rearing does extend further downstream, the area used to quantify HEP values is considered a reasonable estimate of habitat area.

Measure 1, modernization of the shutters into an automatic 7(1)-2 mode would produce an associated HSI increase of 0.7. This HSI increase would result in a gain of habitat value of 1,105 AAHUs.

Measure 2, reconfiguration of the shutters as part of the future without-project condition would provide an HSI increase of 0.2. This future condition would result in a gain of habitat value of 315.7 AAHUs. This value was subtracted from the gain produced by Measure 1 so as to reflect the incremental accomplishments of Measure 1.

Performance Standard. The proper operation of the modernized shutter system should be monitored monthly to ensure the shutters operate correctly and deliver expected temperature reductions downstream.

Costs and Benefits. The total costs and benefits of the fisheries ecosystem restoration measure are depicted in Table 6-10. The first cost of this measure is estimated at $16,300,000. The O&M cost is estimated at $421,000 per year. The primary benefit of this measure is a decrease in downstream water temperatures within the Lower American River during critical life stages. This measure provides better management of the cold-water pool in Folsom, and the greatest operational flexibility in all year.

TABLE 6-10. Initial Alternatives (Best Buy Plans for Fisheries Ecosystem Restoration)

		Cost					Benefits [1]	
Measures	**IWR Symbol**	**First Cost**	**O&M Cost**	**Annual Cost/ Acre/ Year**	**Acres**	**Annual Cost**	**AAHU Gain/ Acre**	**Total Net Gain AAHUs**
Measure 1	A	16,300,000	421,000	3,457	451	1,559,000	1.75	789.3

[1] Benefits reflect gains from future without project condition

6.3 Selection of the NER Plan

The NER Plan (Table 6-12) was formulated based on the CE/ICA of the recommended plan alternatives for each restoration site. The IWR-Plan model was used to conduct these analyses and the results are shown in Tables 6-5 through 6-8 and Table 6-11. The NER Plan is defined the plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective. As shown, best buy plans were determined at each of the floodplain restoration sites based on the identification of a sharp breakpoint in the incremental cost graph between the selected best buy plan and the next largest best buy plan or optimization of benefits when the cost relative to benefits was determined to be reasonable and there were only proportionate increases in the incremental cost graph. All of the restoration plans were formulated based on the fact that riparian and wetland habitat has been severely diminished throughout the study area and there is a scientific basis for restoring riparian and wetland plant communities to sustain biodiversity within the degraded ecosystem of the LAR.

A best buy plan was selected at each of the 4 identified restoration sites. These lands compose some of the last remaining riverine habitat restoration opportunities in the highly urbanized area that surrounds the American River Parkway corridor. Because of the ecological importance of preservation of this remnant riverine habitat, the ecosystem restoration study team decided to identify a reasonable and implementable plan at each of the 4 floodplain sites as each presents opportunities for the restoration of local and regionally scarce natural resources. These sites have unique hydrologic connectivities to the river system, a ecological function that has been highly degraded over time, and unique location between the river's edge and the levee and built environment of the Sacramento metropolitan area; site conditions that present opportunities for restoration.

Automation of the Folsom Dam temperature control shutter system was included as a separate component of the NER Plan because it is the only measure to address the fisheries objectives of improving adult migration, increasing spawning habitat, reducing egg mortality, and improving rearing habitat and juvenile outmigration for the Central Valley steelhead and the fall/late fall-run chinook salmon, fish species that are Federally listed as threatened and as a candidate, respectively.

TABLE 6-11. Fisheries Ecosystem Restoration Measure

Measure	Increm. Annual Cost/Unit Output	Increm. Output (AAHU)	Increm. Cost	Total Annual Cost	Total AAHUs	Average Cost/ AAHUs	Total First Cost
Measure 1. Sliding shutters with mechanized operation	$3,629	789.3	$2,864,370	$1,559,000	789.3	$1,975	$16.3 m

TABLE 6-12. National Ecosystem Restoration Plan

Measures in the Plan	Increm. Annual Cost/AAHU	Total Annual Cost	Total AAHUs	Average Annual Cost/ AAHUs	Total First Cost
Urrutia (Alternative 9.1). Purchase Land-251 acres; Herbicide/Mechanical removal of non-native invasive plant species-10 acres Grade/plant riparian forest-55 acres; Create side channels -30 acres; Terrace Steep Banks -21 acres; Construct low level bank benches- 4.5 acres;;	$7,520	$617,000	150.18	$4,108	$10,525,000
Woodlake (Alternative 9.2). Purchase Land-283 acres; Excavate Seed Bank to Eradicate Non-Native Invasive Plant Species-60 acres; Seed Grassland–50 acres; Restore Connectivity- 5.5 acres; Grade/Plant Riparian Forest-16 acres; Plant Oak Savanna-25 acres; Plant Oak Woodland-16 acres	$7,645	$306,000	28.95	$7,645	$3,560,000
Bushy Lake (Alternative 9.3). Purchase Land-337 acres; Herbicide/Mechanical Removal of Non-native Invasive Species-20 acres; Excavate Seed Bank -20 acres; Grade/Plant parian Forest-17 acres; Construct Side Channels-3.75 acres; Grade Floodplain for Seasonal Wetlands-18 acres; Terrace Steep Banks/Plant Riparian- 8 acres; Restore Emergent Wetlands-1.75 acres; Install Pump and Delivery System; Plant Oak Savanna-70 acres; Create Storage Wetland-6 acres.	$5,388	$616,000	75.44	$5,022	$7,540,000
Arden Bar (Alternative 9.4). Purchase Land-280 acres; Herbicide/Mechanical Removal of Non-native Invasive Species-110 acres; Excavate Seed Bank-110 acres; Grade/Plant Riparian Forest-31 acres; Plant Oak Savanna-25 acres; Construct low level bank benches-1.5 acre;	$8,992	$239,000	28.79	$8,300	$2,123,000
Temperature Control Shutters (Alternative 9.5). Sliding shutters with mechanized operation	$3,629	$1,559,000	789.30	$2,075	$16,300,000